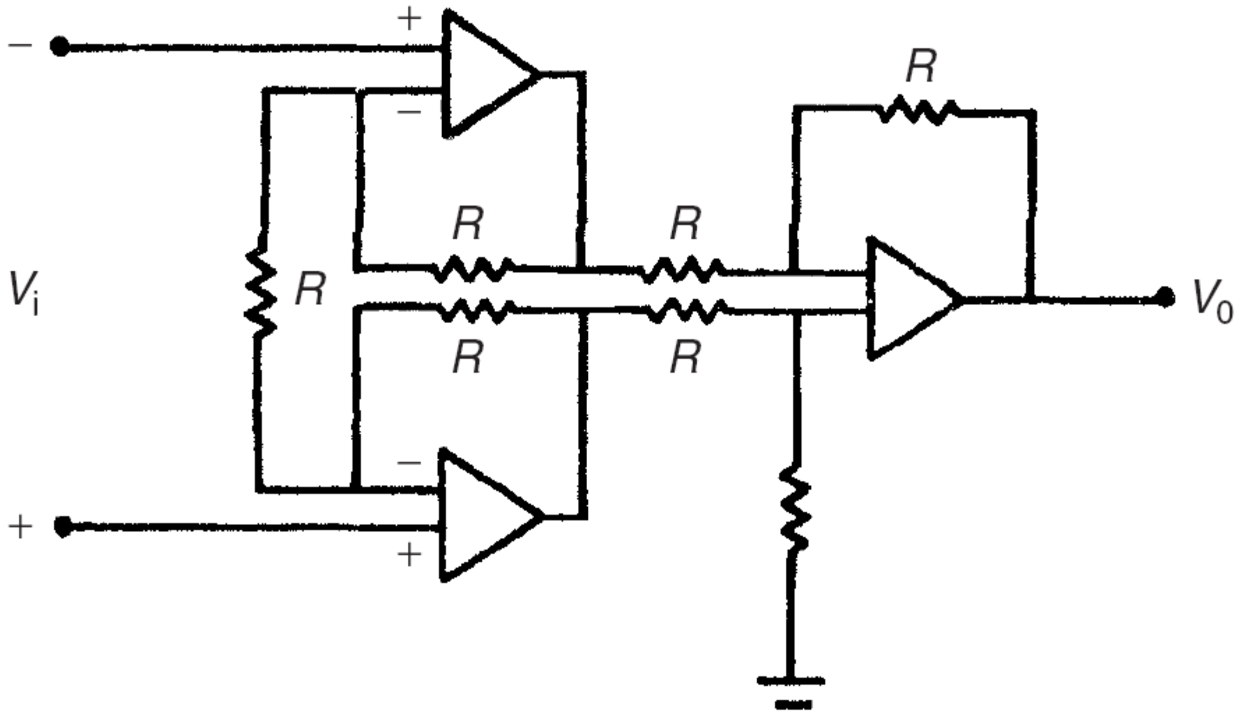
Instrumentation Amplifier

For some applications requiring the amplification of very low level signals, a special type of amplifier known as an instrumentation amplifier is used.



Signal Processing

1. Signal filtering
2. Signal amplification
3. Signal attenuation
4. Signal linearization and
5. Bias removal.

Analog Signal Filtering (1)

Signal filtering consists of processing a signal to remove a certain band of frequencies within it. The band of frequencies removed can be either at:

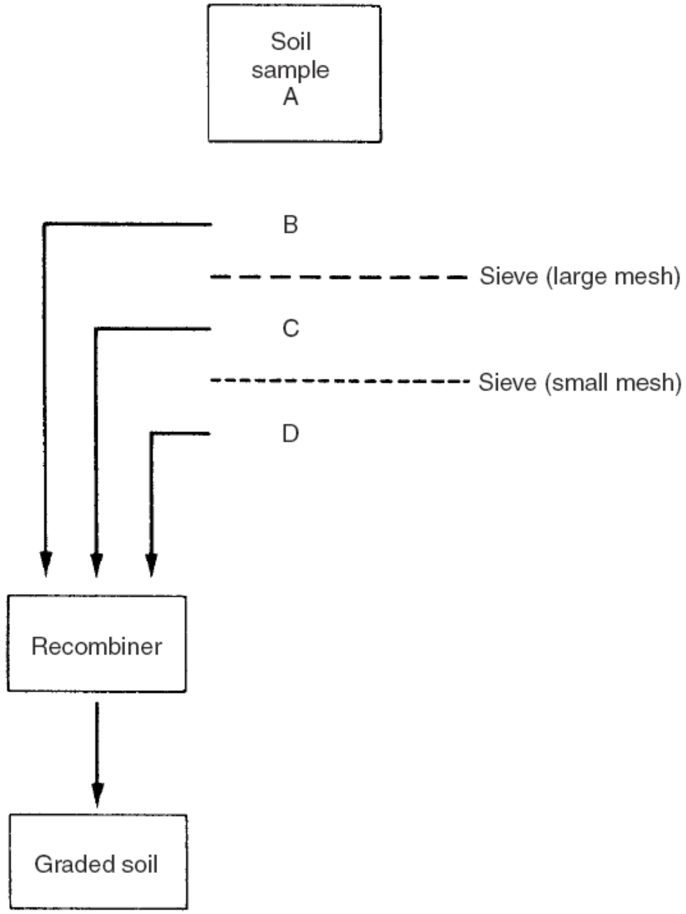
1. Low-frequency end of the frequency spectrum (Low-Pass filter)

2. At the high-frequency end (High-Pass filter)

3. In the middle of the spectrum (band-pass filters and band-stop filters - also known as notch filters)

Analog Signal Filtering (2)

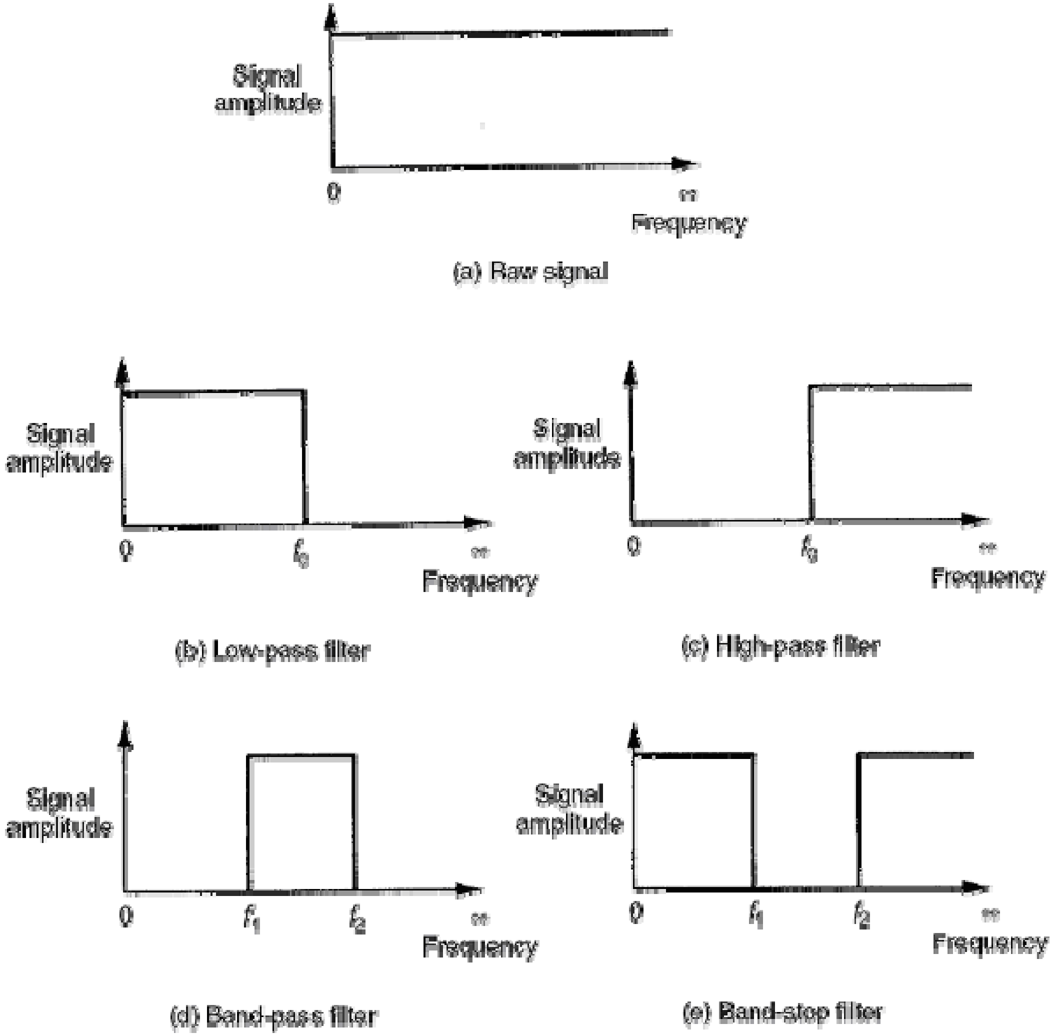
- C+D → Low-Pass filter
- B+C → High-Pass filter
- C → Band-Pass filter
- B+D → Band-stop or notch filter



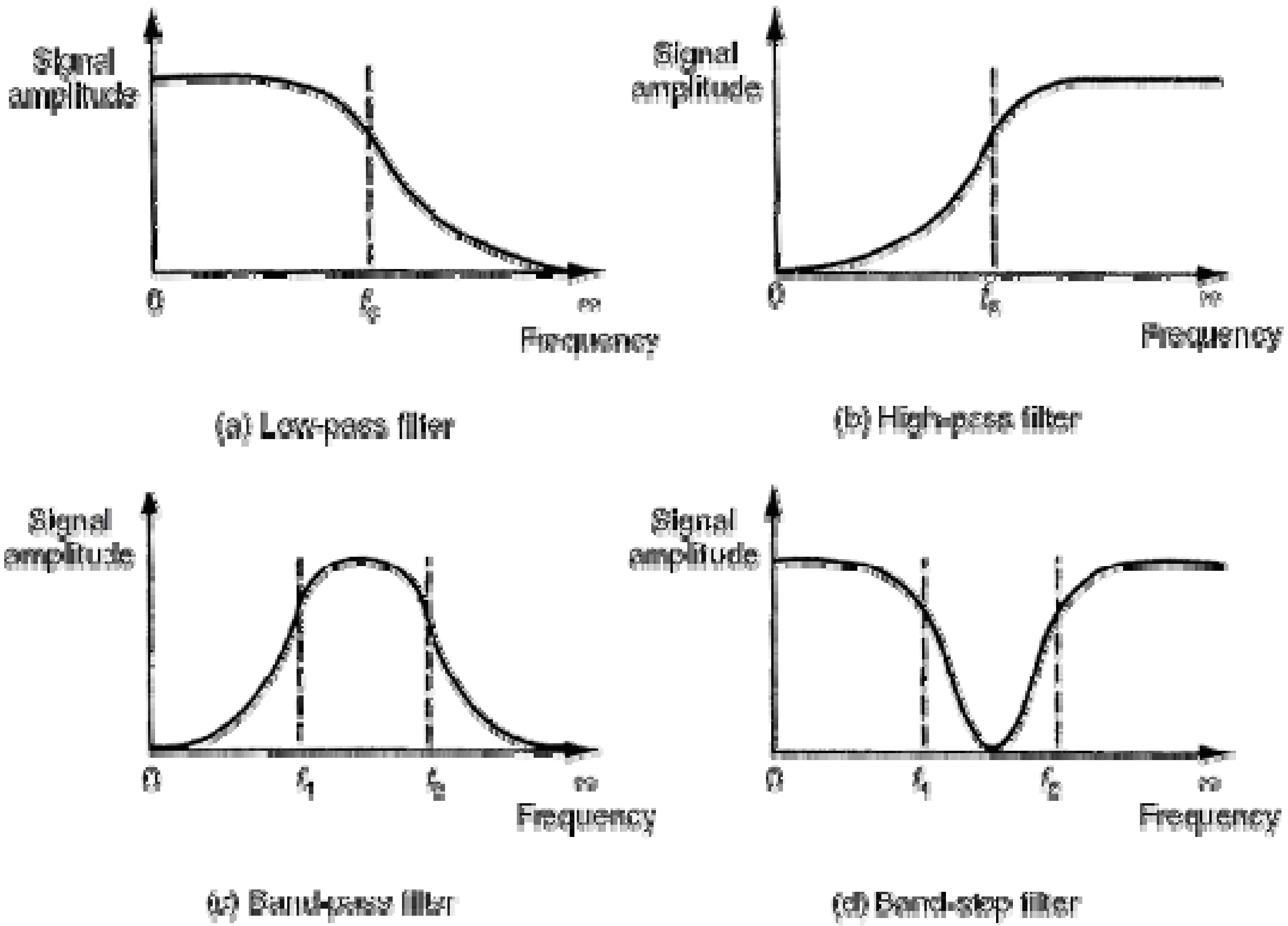
Analog Signal Filtering (3)

- The range of frequencies passed by a filter is known as **the pass band**
- The range not passed is known as **the stop-band**
- The boundary between the two ranges is known as **the cut-off frequency**.

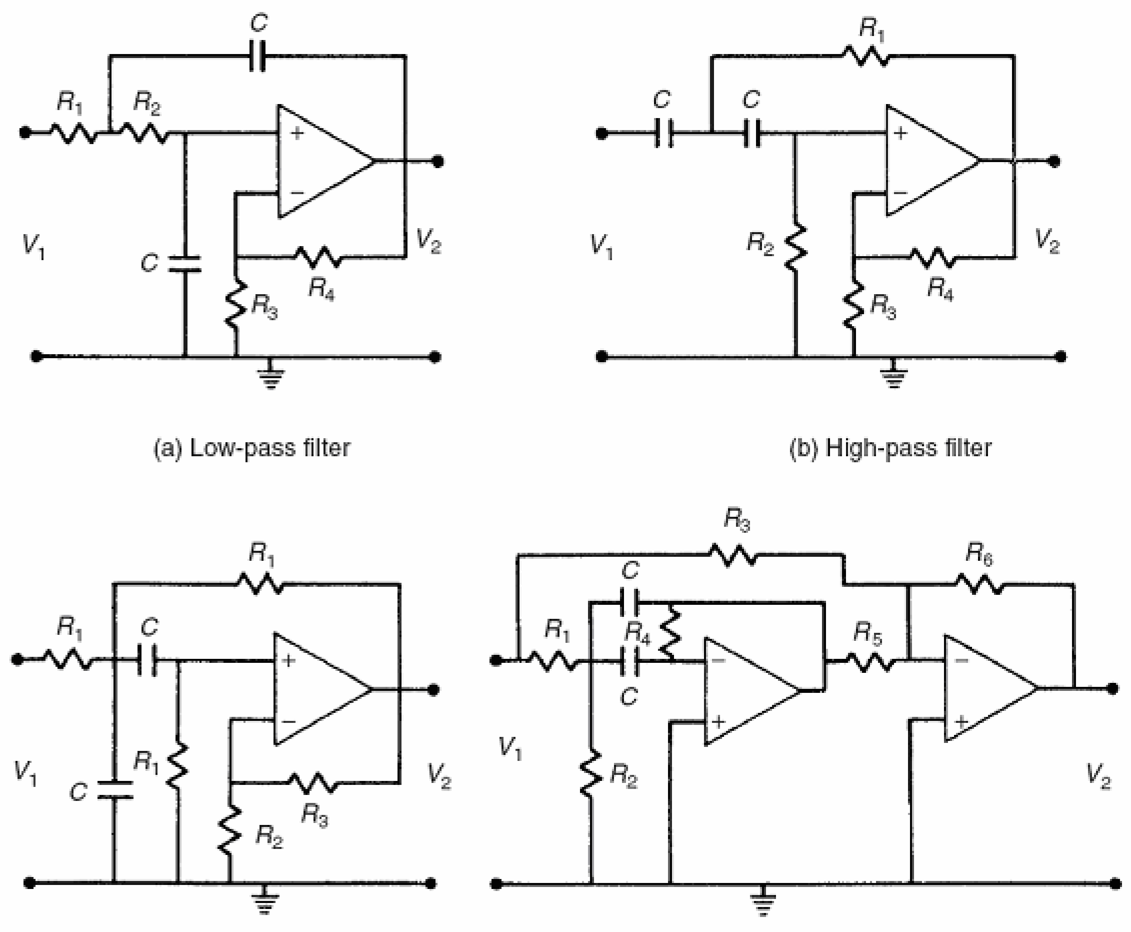
Characteristics of Ideal Filter



Characteristics of Actual Filter



Active Analogue Filters (1)



(a) Low-pass filter

(b) High-pass filter

(c) Band-pass filter

(d) Band-stop filter

Active Analogue Filters (2)

(a) *Low-pass filter*

$$\omega_0 = \sqrt{\frac{1}{R_1 R_2 C_1 C_2}}$$

$$G = 1 + (R_4/R_3)$$

where ω_0 is the cut-off frequency and G is the filter gain (at d.c.).

(b) *High-pass filter*

$$\omega_0 = \sqrt{\frac{1}{R_1 R_2 C_1 C_2}}$$

$$G = 1 + (R_4/R_3)$$

where ω_0 is the cut-off frequency and G is the filter gain (at infinite frequency).

(c) *Band-pass filter*

$$\omega_0 = \frac{\sqrt{2}}{R_1 C}$$

$$\omega_1 = \omega_0 - \frac{4 - G}{2R_1 C}$$

$$\omega_2 = \omega_0 + \frac{4 - G}{2R_1 C}$$

$G =$ filter gain (at frequency ω_0) $= 1 + R_3/R_2$ where ω_1 and ω_2 are frequencies at ends of the pass-band, and ω_0 is centre frequency of the pass-band.

(d) *Band-stop filter*

$$\omega_0 = \sqrt{\frac{1}{R_4 C^2}\left(\frac{1}{R_1} + \frac{1}{R_2}\right)}$$

$$\omega_1 = \omega_0 - \frac{1}{R_4 C}$$

$$\omega_2 = \omega_0 + \frac{1}{R_4 C}$$

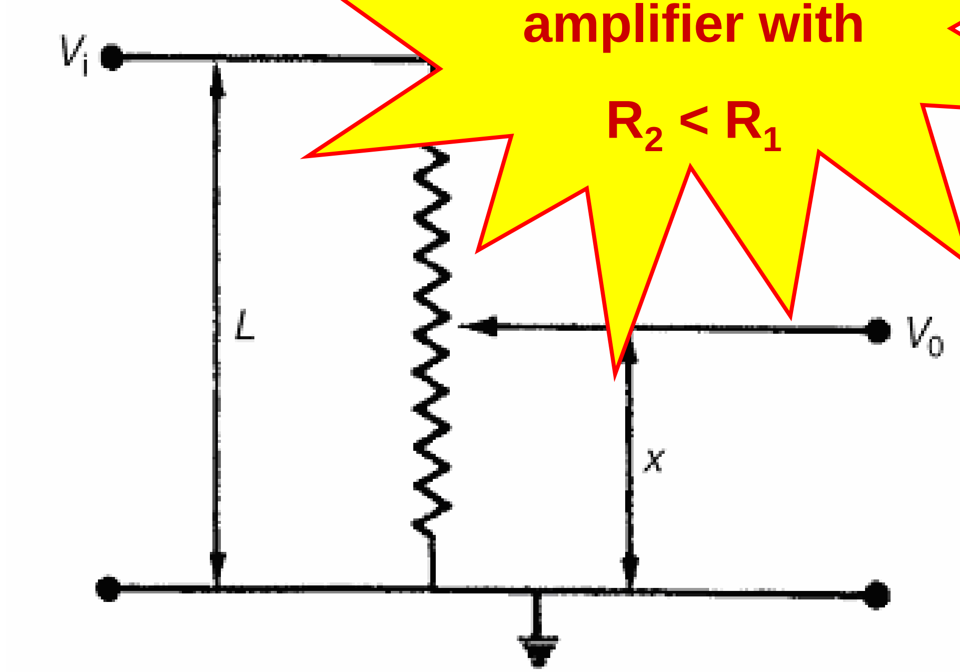
$G =$ filter gain (at d.c. and also high frequency) $= -R_6/R_3$ where ω_1 and ω_2 are frequencies at ends of the stop-band, and ω_0 is centre frequency of the stop-band.

Signal Attenuation

Or use Inverting amplifier with

$R_2 < R_1$

$$V_o = \frac{x \cdot V_i}{L}$$



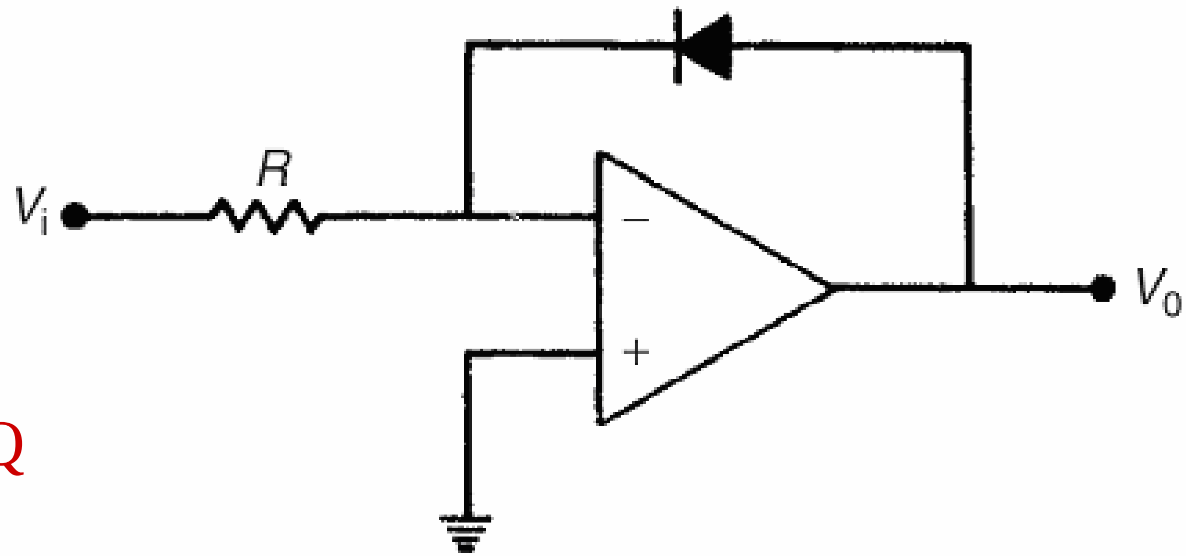
Potentiometer in voltage-dividing circuit

Signal Linearization

$$V_{o,\,sensor} = K\,e^{-\alpha Q}$$

$$V_o = C\,\ln\left(V_i\right)$$

$$V_o = C\,\ln\left(K\right) - \alpha\,C\,Q$$



Op-amp connected for signal linearization

Bias (Zero Drift) Removal

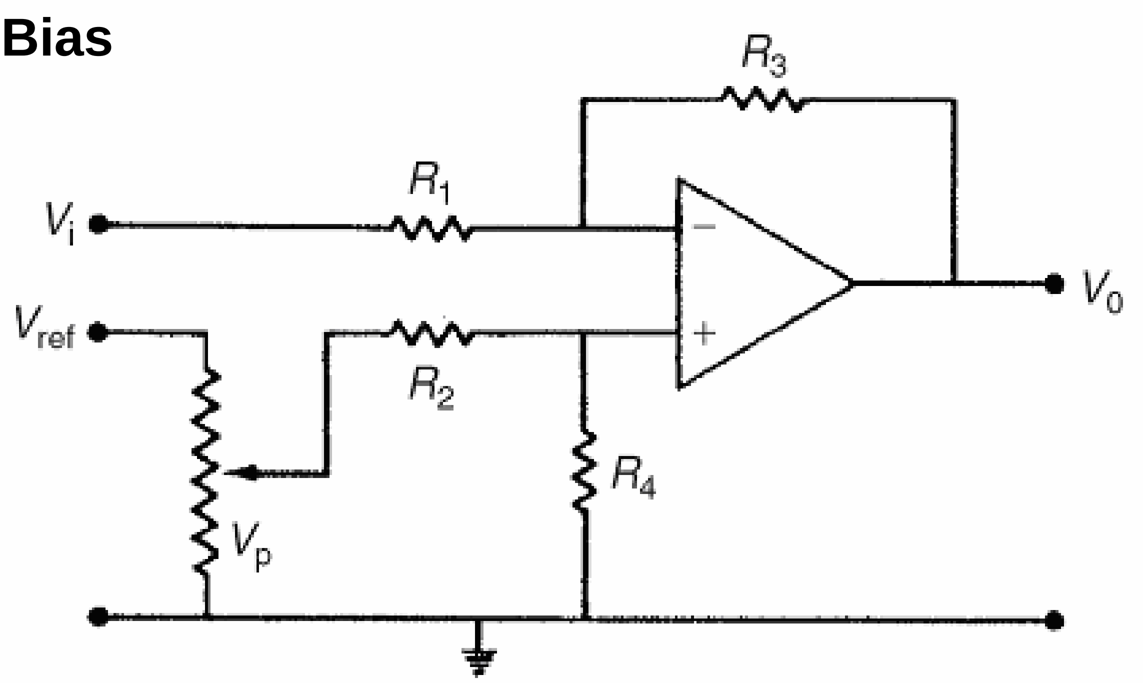
Bias

$$y = K\,x + C$$

$$V_o = \frac{R_3}{R_1}\left(V_p - V_i\right)$$

$$y = K'x$$

K´ = -K (R3/R1)



Bias removal circuit


Thank You!